COST REDUCTION STUDY OF AUTOMOTIVE PART USING DFA METHOD:
REAR LAMP

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SUPERVISOR'S DECLARATION

We hereby declare that we have checked this report and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Automotive Engineering.

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STUDENT'S DECLARATION

I hereby declare that the work in this report is my own except for quotations and summaries which have been duly acknowledge. The report has not been accepted for any degree and is not concurrently submitted for award of other degree.

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ABSTRACT

This thesis deals with the study of assembly analysis of the rear lamp of a car by using Boothroyd Dewhurst DFA method and Hitachi AEM DFA method. The design for assembly of the rear lamp is analyzed based on design efficiency for both methods and the options available are suggested, analyzed and compared with the original design of the rear lamp. The project aimed to reduce the assembly cost of the rear lamp due to the production cost of the rear lamp in industries is high and the demand for the product is increased. From the result and discussion of this thesis, option 3 is the best option for the redesign of the rear lamp. For Boothroyd DFA method, design efficiency for option 3 is 65.7% while the original design efficiency is 48.9% and the design efficiency increased by 16.8%. Then, for Hitachi AEM DFA method, the design efficiency for option 3 is 83.3% while the original design efficiency is 75.7% and the design efficiency increased by 7.6%. The option of redesign with the higher percentage value of design efficiency is selected as the best design in term of its assembly efficiency.

ABSTRAK

Tesis ini berkaitan dengan kajian analisis pemasangan lampu belakang kereta dengan menggunakan kaedah DFA Boothroyd Dewhurst dan kaedah Hitachi AEM DFA.Rekabentuk untuk pemasangan lampu belakang dianalisis berdasarkan kecekapan rekabentuk untuk kedua-dua kaedah dan pilihan yang tersedia yang disarankan, dianalisis dan dibandingkan dengan rekabentuk asli lampu belakang. Projek ini bertujuan untuk mengurangkan kos pemasangan lampu belakang kerana kos pengeluaran lampu belakang dalam industri adalah besar dan permintaan produk meningkat. Daripada hasil dan pembahasan tesis ini, pilihan 3 adalah pilihan terbaik untuk merekabentuk kembali lampu belakang kereta.Untuk kaedah DFA Boothroyd, kecekapan rekabentuk untuk pilihan 3 adalah 65,7% sedangkan kecekapan rekabentuk asalnya adalah 48,9% dan kecekapan rekabentuk meningkat sebanyak 16,8%. Kemudian, untuk Hitachi kaedah DFA AEM, kecekapan rekabentuk untuk pilihan 3 adalah 83.3% sedangkan kecekapan rekabentuk asalnya adalah 75,7% dan kecekapan rekabentuk meningkat sebanyak 7.6%. Pilihan rekabentuk semula dengan nilai peratusan lebih tinggi kecekapan rekabentuk dipilih sebagai rekabentuk terbaik dalam kecekapan pemasangan.

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LIST OF SYMBOLS

E_{ma}	Design efficiency
Nmin	Theoretical minimum number of parts
Ta	Total assembly time
Tma	Estimated time to complete the assembly of the product
E	Assemblability evaluation score ratio
K	Assembly cost ratio
α	Rotational symmetry of a part about an axis perpendicular to its axis of insertion
β	Rotational symmetry of a part about its axis of insertion

LIST OF ABBREVIATIONS

NM	Theoretical minimum number of parts
TM	Total assembly time
DFA	Design for Assembly
DFM	Design for Manufacture
DFMA	Design for Manufacture and Assembly
AEM	Assemblability Evaluation Method
HR	Handling ratio

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This chapter discussed about project background such as problem statement, objectives and scope of the project. This project is focused on replication DFMA (Design for Manufacture and Assembly) method to reduce assembly cost of car rear lamp. DFMA method is the combination of DFA (Design for Assembly) and DFM (Design for Manufacture). Design for manufacturability (DFM) is the general engineering art of designing products in such a way that they are easy to manufacture. DFM is intended to prevent product designs that simplify assembly operations but require more complex and expensive components, designs that simplify component manufacture while complicating the manufacture process and designs that are simple and inexpensive but are difficult or expensive to service and support.(Boothroyd *et al*., 1994)

Design for Assembly is a process by which products are designed with ease of assembly in mind. If a product contains fewer parts it will take less time to assemble, thereby reducing assembly costs. In addition, if the parts are provided with features which make it easier to grasp, move, orient and insert them, this will also reduce assembly time and assembly costs. The reduction of the number of parts in an assembly has the added benefit of generally reducing the total cost of parts in the assembly. This is usually where the major cost benefits of the application of design for assembly occur. (Boothroyd *et al*., 2002)

1.2 PROJECT BACKGROUND

At night, the vehicle need to be seen at night from the rear and it is provided by rear position lamps (also called tail lamps, taillights or tail lights). These are required to produce only red light, and to be wired such that they are lit whenever the front position lamps are illuminated including when the headlamps are on. Rear position lamps may be combined with the vehicle's brake lamps, or separate from them. In combined-function installations, the lamps produce brighter red light for the brake lamp function, and dimmer red light for the rear position lamp function. The tail and brake light functions may be produced separately and/or by a dual-intensity lamp.

The background of car rear lamp started from 1968 to 1971 with Ford Thunderbird could be ordered with additional high-mounted brake and turn signal lights. These were fitted in strips on either side of its small rear window. The Oldsmobile Toronado from 1971 to 1978, and the Buick Riviera from 1974 to 1976 had dual high-mounted supplemental brake lights or turn signals as standard, and were located just below the bottom of the rear window, visually aligned with the conventional rear tail lights/brake lights/turn signals just above the rear bumper. These innovations were not widely adopted at the time. (Taylor et al.,1981)

Automotive and lamp manufacturers in Germany experimented with dual high-mount supplemental brake lamps in the early 1980s, but this effort, too, failed to gain wide popular or regulatory support. Early studies involving taxicabs and other fleet vehicles found that a third stop lamp reduced rear end collisions by about 50%. The lamp's novelty probably played a role, since today the lamp is credited with reducing collisions by about 5%. In 1986, the United States National Highway Traffic Safety Administration and Transport Canada mandated that all new passenger cars have a CHMSL installed. A CHMSL was required on all new light trucks and vans starting in 1994. CHMSLs are so inexpensive to incorporate into a vehicle that even if the lamps prevent only a few percent of rear end collisions they remain a cost-effective safety feature. (Gaudean,1996).

To provide illumination to the rear when backing up, and to warn adjacent vehicle operators and pedestrians of a vehicle's rearward motion, each vehicle must be equipped with at least one rear-mounted, rear-facing reversing lamp (or "backup light"). These are currently required to produce white light by U.S. and international ECE regulations. However, some countries have at various times permitted amber reversing lamps. In Australia and New Zealand, for example, vehicle manufacturers were faced with the task of localizing American cars originally equipped with combination red brake or turn signal lamps and white reversing lamps.

Those countries' regulations permitted the amber rear turn signals to burn steadily as reversing lamps, so automakers and importers were able to combine the rear turn signal and reversing lamp function, and so comply with the regulations without the need for additional lighting devices. Both Australia and New Zealand presently require white reversing lamps, so the combination amber turn/reverse lamp is no longer permitted on new vehicles. The U.S. state of Washington presently permits reversing lamps to emit white or amber light. (Hitzemeyer et al., 1997)

Design for manufacture and assembly (DFMA) is a combination of design for assembly (DFA) and design for manufacture (DFM). The term DFMA is defined as a set of guidelines developed to ensure that a product is designed so that it can be easily and efficiently manufactured and assembled with a minimum labor effort, assemble time, and cost to manufacture the product. During a product development, DFMA method ensures that the transition from the design phase to the production phase is smooth and rapid as possible. (Boothroyd *et al*., 2002)

Generally, there are three DFA methods used to reduce the cost of the product. The first method are Boothroyd-Dewhurst DFA method, Lucas-Hull DFA method, and Hitachi Assembly Evaluation Method (AEM). These three methods are discussed further in Chapter 2. This project is about applying Boothroyd-Dewhurst DFA method and Hitachi AEM method to redesign the car tail lamp to make it better than the previous design in the aspect of assembly efficiency. This case study focused on redesigning the car tail lamp and the aim of the analysis is to evaluate the redesign of the car tail lamp in term of the assembly efficiency.

1.3 PROBLEM STATEMENT

The invention of car has change the world of transportations and the demand for the car is increased especially in the millennium of the new technologies of the car invention. The production of the car by the factories is increased due to the high demand from the customers and same case for the parts of the car produced by the factories. The cost of making the parts is high in the aspects of manufacturing and assembly the parts of the cars. In this project, the rear lamp of the car is investigated to reduce the assembly cost of the part. Car tail lamp consists of many components and parts from the bulb to the reflector of the lamp. In industries, the components of the lamp are assembled together to produce the final component of the car tail lamp. During assembly process, some intricate components are difficult to be assembled. This intricate component also need more time to be assembled and as a result, the cost to assemble the car tail lamp is increased. In solving the increasing cost of car tail lamp assembly, this project is done. The project also aims to minimize the difficulties encountered during assembly of the components of the lamp. At the same time cost of the car tail lamp also aimed to be reduced.

1.4 PROJECT OBJECTIVES

There are three objectives have been defined to be focused on and to simplify the project as stated below:

(i) To evaluate the design efficiency of the product using Boothroyd-Dewhurst DFA method and Hitachi AEM DFA method.
(ii) To make the suggestions to reduce assembly cost of car rear lamp.
(iii) To determine assembly cost of the rear lamp before and after improvements.

1.5 SCOPE OF STUDY

The following scopes of the project are determined in order to achieve the objectives of the project. Firstly, the original design and the improvements of the design are performed by using Solidworks 2010 software. Secondly, the analysis of the original design and the improvement of the design of car tail lamp is performed by using Boothroyd-Dewhurst DFA method and Hitachi AEM DFA method. Thirdly, the suggestions to reduce the assembly cost of the rear lamp are performed and the final scope of study is the assembly cost of the original design and the improvements of the design of the rear lamp is calculated and compared with the original design.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter discussed about the DFA and its guidelines principle. The literature reviews gives a brief explanation about the functions and the principles of the DFA which is subcomponent of the DFMA method.

2.2 DESIGNS FOR ASSEMBLY (DFA)

Design for Assembly (DFA) is an approach to reduce the cost of the product and time of assembly by simplifying the product and process. The DFA method should be considered at all stages of the design process especially in the early stages (Boothroyd *et al*., 1994). It should give serious consideration to ease assembly of the product or subassembly. DFA tool is needed to effectively analyze the ease of assembly of the products or subassemblies it design and it should ensure consistency and completeness in evaluation of product assemblability. It should also eliminate subjective judgement from design assessment, allow free association of ideas, enable easy comparison of alternative design, ensure that solution are evaluated logically, identify assembly problems area and suggest alternative approaches for simplifying the product thus reducing manufacturing and assembly cost. (Boothroyd *et al*., 2002)

By applying a DFA tool, communication between manufacturing and design engineering is improved, and ideas, reasoning, and decisions made during the design process become well documented for future reference. (Baizura,2007)

2.3 General Design Guidelines for Manual Assembly

The process of manual assembly can be divided naturally into two separate areas, handling (acquiring, orientating and moving parts) and insertion and fastening (mating a part to another part or group of parts). The following design form manual assembly guidelines specifically address each of these areas.

2.3.1 Design Guidelines for Part Handling

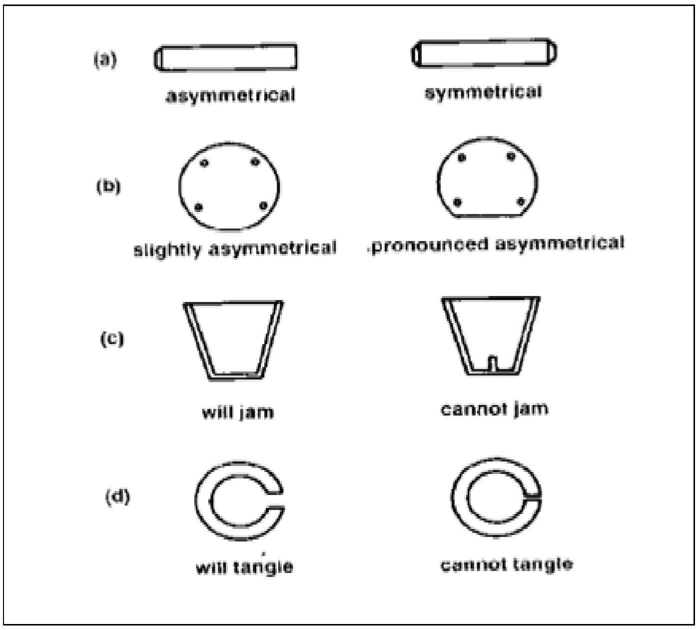

Figure 2.1: Geometrical features affecting part handling
Source: (Boothroyd *et al*., 2002)

(i) Design parts that have end-to-end symmetry and rotational symmetry about the axis of insertion. If this cannot be achieved, try to design parts having the maximum possible symmetry (see Figure 2.1)

(ii) Design parts that, in those instances where the part cannot be made symmetry, are obviously asymmetry (see Figure 2.1)

(iii) Provide features that will prevent jamming of parts that tend to nest or stack when stored in bulk. (see Figure 2.1)

(iv) Avoid features that will allow tangling of parts when parts stored in bulk. (see Figure 2.1)

(v) Avoid parts that stick together or a slippery, delicate, flexible, very small, or very large or that are hazardous to the handler (i.e. parts that are sharp, splinter easily, etc.).(see Figure 2.2).

2.3.2 Design Guidelines for Insertion and Fastening

(i) Design so that there is a little or no resistance to insertion and provide chamfers to guide insertion of two mating parts. (see Figure 2.3)

(ii) Standardize by using common parts, processes, and methods across all models and even across product lines to permit the use of higher volume processes that normally result in lower product cost. (see Figure 2.4)

(iii) Design so that a part is located before it is released. A potential source of problems arises from a part being placed where, due to design constrains. It must be released before it is positively located in the assembly. Under these circumstances, reliance is placed on the trajectory of the part being sufficiently repeatable to locate it consistently (see Figure 2.5)

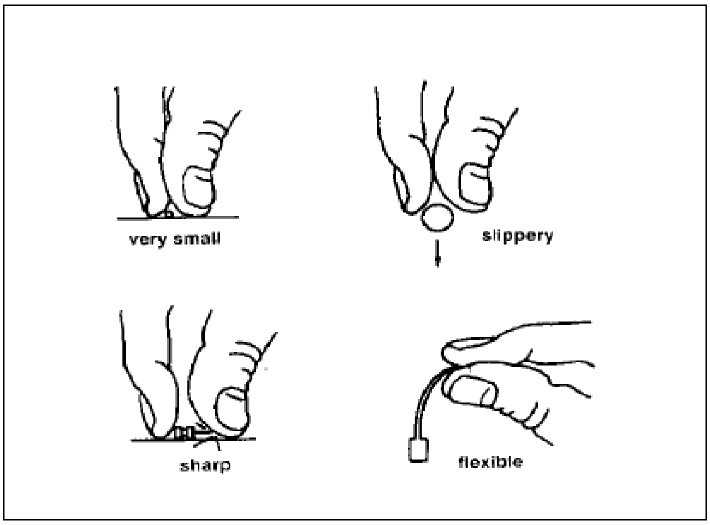

Figure 2.2: Geometrical features affecting part handling.
Source: (Boothroyd *et al*., 2002)

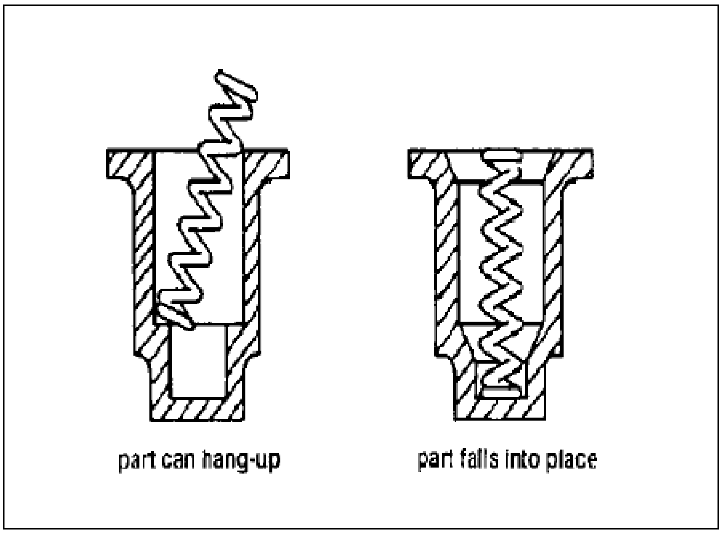

Figure 2.3: Provision of chamfers to allow insertion.
Source: (Boothroyd *et al*., 2002)

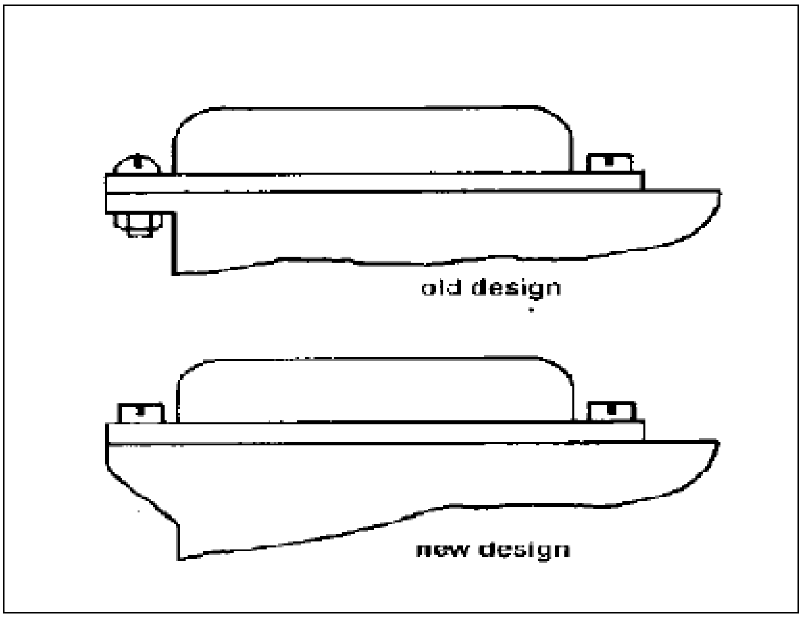

Figure 2.4: Standardize parts assembly

Source: (Boothroyd *et al*., 2002)

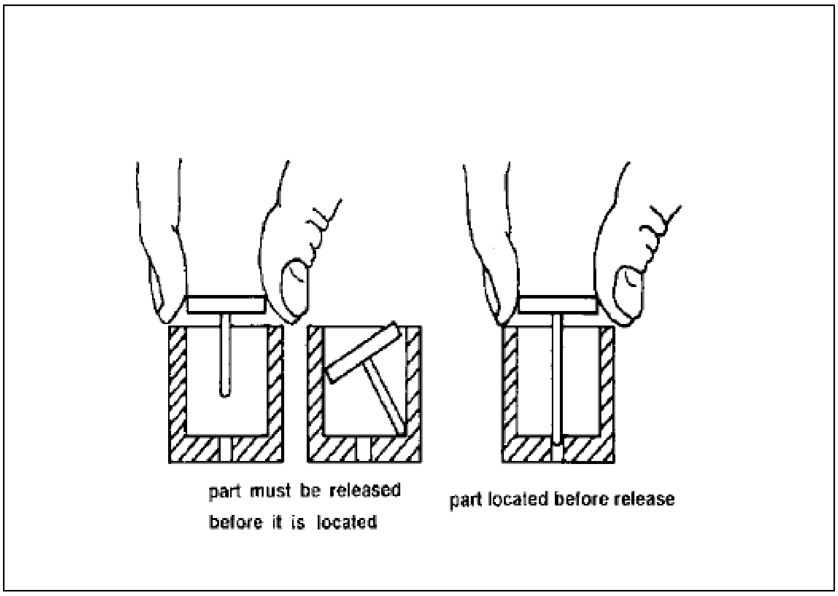

Figure 2.5: Design to aid insertion

Source: (Boothroyd *et al*., 2002)

The DFA guidelines are differ from the various source and it is insufficient for a number of reasons as stated below:

(i) The guidelines will not provide any means to evaluate a design
(ii) Quantitatively for its ease of assembly.
(iii) No relative ranking of all the guidelines that can be used to indicate which guidelines result in the greatest improvements in handling and assembly.
(iv) These guidelines are simply a set of rules which provide the designer with suitable background information to be used to develop a design that will be more easily assembled than a design developed without such a background

If a product contains fewer parts, it will take less time to be assembled, thereby reducing assembly costs. In addition, if the parts are easier to grasp, move, orient and insert, the parts can reduce the assembly time and assembly costs. The reduction of the number of parts in an assembly has benefit and generally reducing the total cost of parts in the assembly. This is usually where the major cost benefits of the application of design for assembly occur.

2.4 DESIGNS FOR ASSEMBLY METHOD

There are three methods that can be used for design for assembly (DFA):

(i) The DFA method exploited by Boothroyd-Dewhurst Inc, USA
(ii) The Hitachi Assemblability Evaluation Method (AEM) by Hitachi Ltd, Japan.
(iii) The Lucas Design for Assembly Methodology by Lucas-Hull, UK.

2.4.1 Boothroyd-Dewhurst DFA Method

In 1977, Geoff Boothroyd, developed the Design for Assembly method (DFA), which could be used to estimate the time for manual assembly of a product and the cost of